

## Comment on “Teleportation with a uniformly accelerated partner”

The authors of Ref. [1] consider teleportation with one of the partners (Rob) being uniformly accelerated and the other (Alice) at rest and conclude that the corresponding fidelity is reduced due to the fact that an observer in a uniformly accelerated frame (i.e., Rob) experiences the Minkowski vacuum (as seen by Alice) as a thermal bath. However, the derivation presented in Ref. [1] does not take into account several crucial features of the scenario under investigation and hence the results of Ref. [1] do not apply in the general case – instead the potential loss of fidelity strongly depends on the explicit physical realization (see the points below). In particular, if cavities are used (which is the assumption of Ref. [1]), the walls of the cavities will keep out the thermal fluctuations (implying that there is no generic loss of fidelity).

**I.** Before Alice and Rob share the entangled state, one has to specify how Rob removes all photons from his cavity – in particular, which particle and vacuum definition Rob adopts in this process: Does he define particles (instantaneously) with respect to the Minkowski time or with respect to his proper (Rindler) time? The natural time coordinate inside an accelerated box is Rindler time: note that not placing the box into the Rindler vacuum state before introducing the entangled particle would be equivalent to using a non-empty box in an inertial entanglement experiment. Furthermore, the evolution depends on the way in which the cavity is accelerated – e.g., whether it is subject to a continuously varying Lorentz length contraction (in the frame of the box) or not. (The temperature experienced by Rob is only relevant if the cavity is not small compared to the characteristic length scale of Rob’s trajectory.) If Rob’s cavity is stationary with respect to Rob’s proper (i.e., Rindler) time, then the corresponding Fulling-Rindler vacuum state inside the cavity is stable under time-evolution and (in this sense) there is no particle creation at all. Otherwise, if the cavity is not stationary with respect to the Rindler time, then one also has to take into account particle creation due to the dynamical Casimir effect (non-inertially moving wall/mirror effect) for non-adiabatic changes.

**II.** Inside a perfectly conducting ideal lossless cavity (as assumed by the authors), the time-evolution of the quantum state is always unitary and hence a pure state remains a pure state. Consequently, in this situation, any fidelity loss can only be induced by an inappropriate measurement (e.g., measuring the wrong kind of particle, see the point above) or by an imperfect generation of the entangled pair at the moment when Alice and Rob coincide (see also the point below). If the pair of photons is perfectly entangled initially and the cavity is assumed to be ideal then there is always a measurement procedure (i.e., a set of positive/negative frequency basis functions) which gives fidelity one.

**III.** Formulae (6) and (7) in Ref. [1] describe the relation of the Minkowski and the Fulling-Rindler modes in a space-time without any boundaries. Therefore, these expressions and hence also the subsequent equations do not describe the cavity modes in general. The application of the thermo-field formalism to the case with cavities requires more detailed considerations – e.g., how does the quantum state within the cavity in the right Rindler wedge *I* get entangled with the state of the field in the left Rindler wedge *II*. In general one can always set up the cavities so there is no entanglement between the cavities in the two wedges. One could of course also set them up so as to have entanglement, by, for example, opening each of the cavities to the Minkowski vacuum outside the cavities for a while.

In summary, the impact of the thermal nature (as experienced by Rob) of the Minkowski vacuum on the fidelity would be expected to be an issue only if Rob attempts to make measurements on unconstrained entangled photons (i.e., without cavities) emitted by Alice, for example. E.g., if the frequency of the photons is not large compared to the temperature experienced by Rob, i.e., their wavelength is not much smaller than the characteristic length scale of Rob’s trajectory, the photons cannot strictly be localized inside of Rob’s horizon and, consequently, Rob cannot recover the full information sent by Alice. In the case with cavities considered in Ref. [1], however, the results obtained there cannot be applied in full generality without additional considerations and a potential loss of fidelity depends upon the various details discussed above.

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Ralf Schützhold<sup>1</sup> and William G. Unruh<sup>2</sup>

<sup>1</sup>Institut für Theoretische Physik

Technische Universität Dresden

01062 Dresden, Germany

<sup>2</sup>Department of Physics and Astronomy

University of British Columbia

Vancouver B.C., V6T 1Z1 Canada

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[1] P. M. Alsing and G. J. Milburn, Phys. Rev. Lett. **91**, 180404 (2003); [quant-ph/0302179].